



Ballistic parameters of cal. 9 mm × 17 mm industrial blank cartridges (cattle cartridges)

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ABSTRACT

Introduction: Cal. 9 mm × 17 mm industrial blank cartridges deserve special interest in the field of forensic ballistic. This calibre is most often used in Kerner-type livestock stunners, but also in different power tools. The legal framework of these industrial blank cartridges is provided by the C.I.P. and DIN 7260 regulations. The aim of this investigation is to describe and compare two experimental test procedures for measurement of maximum gas pressure and kinetic energy of cal. 9 mm × 17 mm industrial blank cartridges according to standardized C.I.P. and DIN 7260 protocols and to provide these ballistic data.

Methods: Using two different pressure measurement barrels and standardized test projectiles, the maximum gas pressure and the kinetic energy of the test projectiles are investigated. While the pressure take-off point in C.I.P. protocol is at the cartridge mouth, the DIN 7260 protocol is modified using a pressure take-off point in the cartridge chamber. For each test protocol (C.I.P. and DIN), maximum gas pressure, velocity, impulse and energy of the test projectiles are measured. Each ten cartridges from the same ammunition lot of four different energy levels (red, blue, yellow, green) are investigated.

Results: While the cartridge energy values are comparable between the two different test protocols, maximum gas pressure measured in the DIN set-up (3907 bar) far surpasses the gas pressure in the C.I.P. protocol (1586 bar). Both test protocols observed higher energy values of the green and yellow cartridges than regulated in DIN 7260.

Conclusion: Enormous gas pressure values of more than 3900 bar emphasize the power of industrial blank cartridges. Once again, the harmlessness of these blank cartridges and the weapons/tools that are operated with these propellants is refuted.

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1. Introduction

Cal. 9 mm × 17 mm industrial blank cartridges deserve special interest in the field of forensic ballistic. As this calibre is widely used in so-called “Kerner-type” captive bolt stunners (slaughterer’s guns) it is also known under the designation “cattle cartridge” [1]. Injuries caused by livestock stunners traditionally play an important role in the forensic medicine of German-speaking countries and numerous cases of suicide and even homicide due to these captive bolt pistols have been reported [2]. The muzzle velocity of these cartridge actuated captive bolt pistols is reported to be less than 50 m/s [3]. Although, no investigations

on the ballistic parameters of the 9 mm × 17 mm blank cartridge itself have been published.

The propellant of cal. 9 mm × 17 mm industrial blank cartridges is made of a nitrocellulose and nitroglycerine mix and therefore called a double base powder. Double base powders have a higher energy potential than single base powders which are made of a nitrocellulose base only. They release their energy by deflagration, a process of rapid chemical burning. This rapid burning produces a huge volume of expanding gasses which, if confined in the chamber of the power tool, accelerate the fastening bolt or the mechanical component part down the barrel, producing a high velocity in a very short distance.

Whereas the outer dimensions of the cal. 9 mm × 17 mm industrial blank cartridges are equivalent to .380 blank cartridges or 9 mm blank cartridges, the powder charge and the energy of the cartridges are completely different. While the powder charge of .380 or 9 mm P.A. blank cartridges measures between 150 mg and 211 mg, 9 mm × 17 mm industrial blank cartridges contain a charge of up to 460 mg powder [4,5].

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The basis for weapons and firing laws in many countries is the C.I.P. (Commission Internationale Permanente pour l'épreuve des armes à feu portatives) which is a State International Organisation composed of thirteen countries. The Permanent International Commission for the Proof of Small Arms (C.I.P.) has the mission to proof hunting, target shooting, and defensive weapons with the exception of those intended for land, sea, or air warfare. It has also the mission to proof all other portable devices weapons, or industrial or professional tools which make use of an explosive substance to propel either a projectile or some other mechanical component part. These industrial or professional tools are: riveting guns, cattle killers, alarm weapons, industrial guns, warning or signalling devices [6].

Though these cal. 9 mm \times 17 mm blank cartridges are most often used to operate livestock stunners, the German National Proof House (PTB, Physikalisch-Technische Bundesanstalt) lists 22 different tools to be operated with cal. 9 mm \times 17 mm industrial blank cartridges (captive bolt stunners 11, vole captive bolt devices 4, riveting tools/nail guns 2, alarm weapons 1, bomb disposal apparatus 1, auxiliary barrel as dummy launcher 3) [7]. Due to the reciprocal acceptance of proof test marks, these tools are also approved within all 13 C.I.P. member states.

Germany is the only country of origin of the cal. 9 mm \times 17 mm industrial blank cartridges. The statutory framework of the fabrication and usage of this ammunition consists of both the C.I.P. and DIN 7260 regulations. While the C.I.P. regulations limit the maximum gas pressure to a pressure of 1450 bar (1450×10^5 Pa), the DIN 7260 regulations assign certain colour marks at the headstamp to different power charges and different maximum energy levels (Fig. 1) [8].

1.1. Aim of this investigation

The aim of this investigation is to describe and compare two experimental test procedures for measurement of maximum gas pressure and kinetic energy of cal. 9 mm \times 17 mm industrial blank cartridges according to standardized C.I.P. and DIN 7260 protocols. These ballistic parameters are determined for cal. 9 mm \times 17 mm industrial blank cartridges of all four obtainable energy values (red, blue, yellow, green) and provided in this work.

2. Materials and methods

2.1. Measurement of maximum gas pressure and kinetic energy of industrial cartridges according to C.I.P. regulations

The experimental test set-up consists of a pressure measurement block containing a pressure measurement barrel (heat-treatable steel, inside diameter/cal. 16 mm, length from end of cartridge chamber 200 mm) and a chamber able to



Fig. 1. Cartridge cases and ammunition headstamps ("9 \times 17 RWS") of cal. 9 mm \times 17 mm industrial blank cartridges. The maximum energy of the cartridge is colour-coded at the primer cap (red 1050 J, blue 850 J, yellow 700 J, green 600 J). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

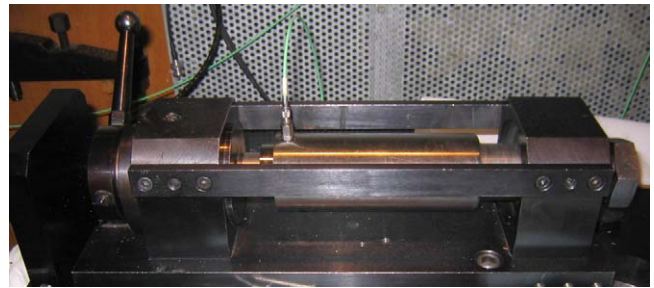


Fig. 2. Pressure measurement block with pressure measurement barrel. The barrel contains a bore hole (diameter 3 mm) for the piezo-electric transducer (Type 6215, Kistler Instrumente AG, Winterthur, Switzerland).



Fig. 3. Standardized test projectiles for measurement of kinetic energy of cal. 9 mm \times 17 mm industrial blank cartridges (left: cal. 16 mm, mass 80 g piston/plunger according to C.I.P., right cal. 9 mm, mass 13.6 g piston/plunger according to DIN 7260). The crossed slots of the C.I.P. piston (left) must lie in the axis of the groove of the transducer.

accept fully the cal. 9 mm \times 17 mm cartridge (Fig. 2). The barrel contains a bore hole (diameter 3 mm) for the piezo-electric transducer (Type 6215, Kistler Instrumente AG, Winterthur, Switzerland) located at the measurement take-off point which is at 1.5 mm from the end of the cartridge chamber.

Measurements were taken with the barrel horizontal. The cartridge was inserted into the chamber in such a way that the propellant is next to the primer cap. For measurement of kinetic energy a standardized test projectile (semi-hardened steel piston/plunger, mass 80 g, diameter 16 mm) was loaded into the barrel in front of the cartridge mouth. The crossed slots of the piston were in the axis of the groove of the transducer (Fig. 3). The cartridge was fired by a percussion mechanism with a firing pin.

Gas pressure of each ten commercial industrial blank cartridges (RWS Dynamit Nobel, Germany, calibre 9 mm \times 17 mm) from the same ammunition lot of the energy values green, yellow, blue and red were measured. Kinetic parameters of the test projectiles were measured with a photoelectric light barrier between 0.5 m and 1.5 m from the muzzle [9].

The measurement chain was completed by two charge amplifiers to convert the signals provided by the piezo-electrical transducer and the light barrier into a voltage (Type 5015A, Kistler Instrumente AG, Winterthur, Switzerland).

2.2. Measurement of maximum gas pressure and kinetic energy of industrial cartridges according to DIN 7260

The test set up and the measurement chain was as described above. In contrast, according to DIN 7260 the calibre of the test barrel was 9 mm and the standardized test projectile was a cal. 9 mm steel piston/plunger (mass 13.6 g) (Fig. 3).

The measurement take-off point was located within the cartridge chamber. Therefore, the cartridge cases were pierced concentrically (diameter of the drill hole 2 mm) and coaxial with the pressure take-off channel. Obturation of the hole drilled in the case of the cartridges was achieved by a heat-resistant adhesive tape.

2.3. Data analysis and processing

Dynamic measurements of the cartridges' gas pressure and the velocity of the test projectiles were analysed. The kinetic energy of a projectile is half the product of its mass multiplied by square of the velocity. According to C.I.P. and DIN 7260 regulations this formula defines the energy of the industrial blank cartridge, therefore energy of each industrial blank cartridge was calculated by the formula $E = 0.5mv^2$. Impulse of the test projectiles was calculated by the formula $p = mv$.

For both experimental set-ups cartridges from the same ammunition lot were taken. All measurements were taken in a completely enclosed shooting test stand free from weather influences. Calibration of the measuring system was performed before and after each series of measurements (10 shots). Multi channel data acquisition and analysis were performed using Trans PC and TransAS v. 2.6.5 (Elsys AG, Niederrohrdorf, Switzerland). Statistical analysis was performed using SPSS 16.0.1 (SPSS Inc. Chicago/Illinois 60606).

3. Results

3.1. Cartridge gas pressure and cartridge energy according to C.I.P.

The average maximum gas pressure (average P_{\max}) was 1519.76 bar (S.D. 55.84 bar) (1519.76×10^5 Pa, S.D. 55.84×10^5 Pa) for the red, 1348.84 bar (S.D. 73.43 bar) (1348.84×10^5 Pa, S.D. 73.43×10^5 Pa) for the blue, 1363.89 bar (S.D. 81.94 bar) (1363.89×10^5 Pa, S.D. 81.94×10^5 Pa) for the yellow, and 1142.66 bar (S.D. 69.27 bar) (1142.66×10^5 Pa, S.D. 69.27×10^5 Pa) for the green cartridges.

The kinetic energy of the test projectiles was 975.72 J (S.D. 14.08 J) for the red, 904.23 J (S.D. 18.08 J) for the blue, 895.88 J (S.D. 32.20 J) for the yellow, and 818.24 J (S.D. 17.23 J) for the green cartridges.

3.2. Cartridge gas pressure and cartridge energy according to DIN 7260

The average maximum gas pressure (average P_{\max}) was 3690.58 bar (S.D. 102.46 bar) (3690.58×10^5 Pa, S.D. 102.46×10^5 Pa) for the red, 3200.82 bar (S.D. 139.94 bar) (3200.82×10^5 Pa, S.D. 139.94×10^5 Pa) for the blue, 3226.05 bar (S.D. 123.15 bar) (3226.05×10^5 Pa, S.D. 123.15×10^5 Pa) for the yellow, and 2756.85 bar (S.D. 117.49 bar) (2756.85×10^5 Pa, S.D. 117.49×10^5 Pa) for the green cartridges.

The kinetic energy of the test projectiles was 911.99 J (S.D. 19.61 J) for the red, 838.46 J (S.D. 31.18 J) for the blue, 839.00 J (S.D. 11.59 J) for the yellow, and 757.03 J (S.D. 16.33 J) for the green cartridges.

For detailed internal and external ballistic parameters (gas pressure; velocity, muzzle impulse and energy of the test projectiles) see Tables 1 and 2. Development of velocity, impulse and kinetic energy of the test projectiles as a function of cartridge gas pressure are shown in Figs. 4 and 5.

4. Discussion

The main goal of statutory ammunition testing is prevention of hazards due to technical failure while operating weaponry or powder actuated power tools. Therefore a subtle reciprocal adjustment of ammunition and weapons or tools is mandatory which is realized in certain calibres that are defined by their dimension and maximum gas pressure. It is the aim of limiting the maximum gas pressure of ammunition to rule out overstress of weapons or powder actuated tools. On the other hand, only definition of the maximum gas pressure allows stability testing of weaponry or powder actuated tools by test shots prior to initial use after fabrication or repair [10,11].

Determination of ballistic parameters of projectile ammunition is performed by measurement of the gas pressure and of the projectile velocity. In contrast, blank cartridge ammunition

Table 1
Internal and external ballistic parameters of cal. 9 mm × 17 mm industrial blank cartridges according to C.I.P. regulations. Each ten shots were averaged, ranges are given below the average values. Powder charge in mg according to [5].

Colour code charge (mg)	Pressure P (bar)	P (Pa)	P (psi)	Velocity v (m/s)	Impulse p (ns)	Energy E (J)
Red 460	1519.76 (1438.8–1585.8)	1519.76×10^5 (1438.8×10^5 – 1585.8×10^5)	22042.25 (20868.02–23000.08)	156.18 (154.17–157.11)	12.49 (12.33–12.57)	975.72 (950.72–987.30)
Blue 410	1348.84 (1190.9–1419.4)	1348.84×10^5 (1190.9×10^5 – 1419.4×10^5)	19563.27 (17272.54–20586.65)	150.35 (147.53–151.81)	12.03 (11.80–12.14)	904.23 (870.60–921.87)
Yellow 390	1363.89 (1162.5–1439.3)	1363.89×10^5 (1162.5×10^5 – 1439.3×10^5)	19781.55 (16860.63–20875.28)	149.63 (143.27–151.98)	11.97 (11.46–12.16)	895.88 (821.06–923.89)
Green 370	1142.66 (1023.2–1233.0)	1142.66×10^5 (1023.2×10^5 – 1233.0×10^5)	16572.88 (14840.26–17883.15)	143.02 (141.03–145.09)	11.44 (11.28–11.61)	818.24 (795.60–842.01)

Table 2
Internal and external ballistic parameters of cal. 9 mm × 17 mm industrial blank cartridges according to DIN 7260 regulations. Each ten shots were averaged, ranges are given below the average values. Powder charge in mg according to [5].

Colour code charge (mg)	Pressure P (bar)	P (Pa)	P (psi)	Velocity v (m/s)	Impulse p (Ns)	Energy E (J)
Red 460	3690.58 (3558.6–3906.7)	3690.58×10^5 (3558.6×10^5 – 3906.7×10^5)	53527.32 (51613.12–56661.88)	366.20 (358.60–373.90)	4.98 (4.88–5.09)	911.99 (874.44–950.65)
Blue 410	3200.82 (2981.7–3472.7)	3200.82×10^5 (2981.7×10^5 – 3472.7×10^5)	46423.96 (43245.89–50367.24)	351.09 (338.00–363.80)	4.77 (4.60–4.95)	838.46 (776.86–899.98)
Yellow 390	3226.05 (3019.0–3433.9)	3226.05×10^5 (3019.0×10^5 – 3433.9×10^5)	46789.89 (43786.88–49804.50)	351.25 (347.10–354.50)	4.78 (4.72–4.82)	839.00 (819.25–845.56)
Green 370	2756.85 (2547.1–2861.4)	2756.85×10^5 (2547.1×10^5 – 2861.4×10^5)	39984.72 (36942.55–41501.09)	333.64 (328.20–339.50)	4.54 (4.46–4.62)	757.03 (732.46–783.77)

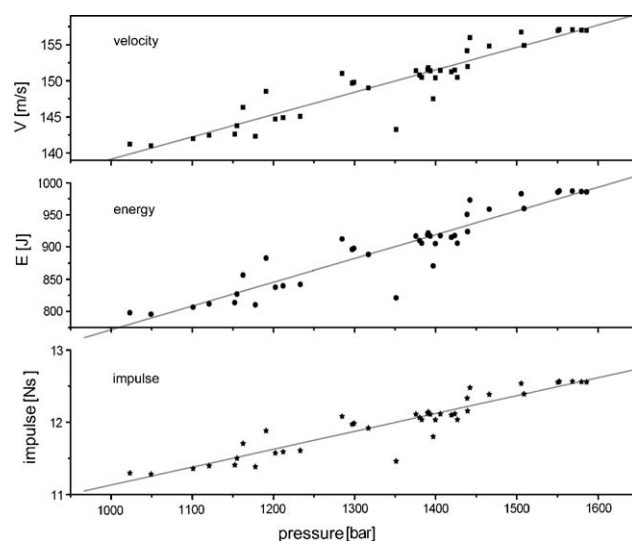


Fig. 4. Development of velocity, kinetic energy and impulse of the 80 g test projectiles as a function of gas pressure according to C.I.P. regulations.

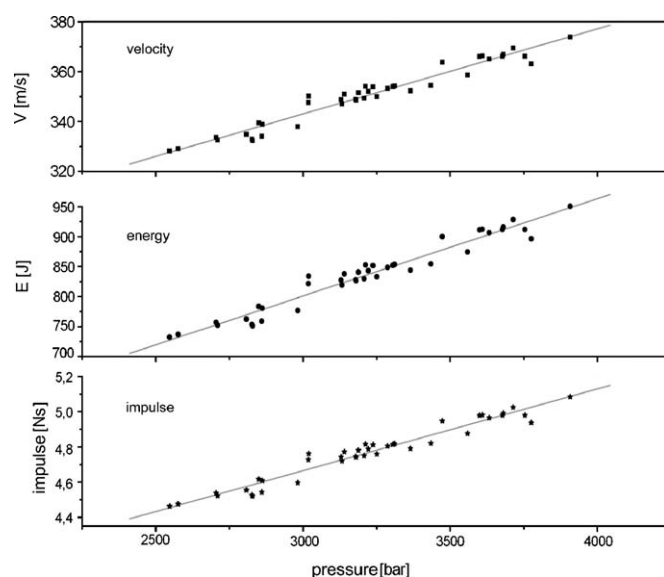


Fig. 5. Development of velocity, kinetic energy and impulse of the 13.6 g test projectiles as a function of gas pressure according to DIN 7260 regulations.

contains no projectile. Therefore, the energy of the blank cartridge is defined by the kinetic energy of a standardized test projectile (piston/plunger) that is loaded in front of the cartridge mouth and shot through a pressure measurement barrel. The formerly used pressure measurement technique where a hole is drilled in the cartridge chamber and a piston fitted that presses on a calibrated copper slug (or crusher) has been largely superseded by piezo-electric transducers as used in this work [12].

The maximum gas pressure in the experimental set-up according to DIN 7260 (up to 3906.7 bar) far surpasses the maximum gas pressure in the C.I.P. set-up (up to 1585.8 bar). Although the measurement point differs (cartridge chamber vs. cartridge mouth), the main reason is the increased combustion space in the C.I.P. set-up due to the higher calibre of the pressure measurement barrel and the test projectile. While the C.I.P. regulations define the firing power of cal. 9 mm × 17 mm industrial blank cartridge on the basis of the gas pressure (maximum 1450 bar), the DIN 7260 regulations do not refer to the gas pressure but to the kinetic energy of the test projectiles. The

gas pressure based on the DIN 7260 set-up has previously not been investigated.

Although the pressure take-off point at the cartridge mouth is mainly used for determination of the maximum gas pressure, it bears certain difficulties. The increase of the pressure curve within the bore hole is very high which may result in certain oscillations of the pressure column and may lead to pressure peaks far beyond the actual maximum gas pressure [12]. This error is eliminated by the crossed slots of the C.I.P.-piston lying in the axis of the groove of the transducer.

On the other hand, pressure take-off at the cartridge chamber might also be susceptible to faults. The cartridge case has to be drilled which makes the combustion space increase marginally and might provoke a leakage between cartridge case and wall of the chamber [12].

Experience shows that generally the kinetic energy of a projectile increases by 10–20% for an increase of pressure of 30% [12]. These findings have been confirmed in our investigation (Figs. 4 and 5).

Gas pressure measurements of cal. 9 mm × 17 mm industrial blank cartridges used in a vole captive bolt device, which is a certain kind of spring gun used as a pest control mean, revealed a maximum gas pressure in the cartridge chamber between 813.6 bar and 1098.3 bar for the yellow cartridge (maximum energy 700 J) [13]. The gas pressure at the cartridge mouth of blank cartridges (calibres 8 mm, .380, 9 mm PA) has been investigated by Kneubuehl and Rothschild in the range of 48–184 bar [14,15]. Gas pressure of the blank cartridges used in vole captive bolt devices or in pressure barrels without test projectiles does not encounter noticeable resistance after bursting the crimping of the case. This results in a free pressure spread and in a pressure maximum far below the maximum gas pressure that was determined in this work by the C.I.P. (up to 1439.3 bar for the yellow cartridge) and DIN 7260 (up to 3433.9 bar for the yellow cartridge) method.

The present investigation reveals the enormous gas pressure that results by the deflagration of cal. 9 mm × 17 mm industrial blank cartridges. Using these industrial cartridges against legal regulations in other shooting devices (e.g. in cal. .380 or 9 mm blank firing handguns) might lead to severe damage due to overload as these shooting devices are not designed for this extreme pressure build-up.

Using industrial cartridges with a higher charge than the power tool is designed for also bears an enormous hazardous potential. For example, vole captive bolt devices are restricted to be operated with yellow cartridges (maximum energy 700 J) only. Higher charges might overstress the shooting apparatus and lead to fatal injuries in case of unintentional discharge [13].

This investigation demonstrates the gas pressure increasing effects by diminishing the combustion space by projectiles loaded in front of the blank cartridge mouth. Manipulating blank cartridge actuated tools or handguns by illegal loading of projectiles in front

of the cartridge mouth poses a hazardous risk both by the projectile itself and by the high gas pressure which might lead to overstress and blasting of the breech or barrel [1,16–19].

5. Conclusion

We presented previously unpublished experimental data on the ballistics of cal. 9 mm × 17 mm industrial blank cartridges. Firing gas pressure attains much higher measuring values in the DIN 7260 procedure compared with the C.I.P. method. As the gas pressure of the same ammunition lot differs depending on the experimental set-up (DIN 7260 or C.I.P.), knowledge of the test set-up and the measuring system is mandatory for the correct interpretation of given ballistic parameters. Once again, the harmlessness of these blank cartridges and the weapons/tools operated with these propellants is refuted.

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